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THE FIRST EGRESS OF MAN INTO SPACE

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In his report, Pavel Ivanovich Belyayev, the commander of the /1 "Voskhod-2" spacecraft, has discussed in some detail our flight, our preparation for it, and our impressions while it was in progress. I must, however, state that from the standpoint of the novelty and unusualness of the impressions received during the spaceflight I was much luckier than my friend and commander. The magnificent picture which I was able to observe directly from open space was so extraordinary, so color-rich and grandiose, that it puts even the boldest fantasy in the shade.

I am very happy that the honor fell to me to be the first of Earth's people to "try" free space and to demonstrate that it is possible for man to perform work outside spacecraft in free fall, which will be extremely necessary for future space study and the organization of interplanetary flights.

Our ship, the "Voskhod-2", our suits and life support systems were painstakingly prepared and checked many times on the ground by the widest variety of specialists. Only when there remained not a single unclear question, not a single element of doubt of the safe completion of the extravehicular activity, only then did our flight receive approval to proceed.

P. I. Belyayev and I completed a tremendous program of different kinds /2 of training prior to our flight. Everything pertaining to the egress into space was worked out several times on the ground to the smallest detail and under the widest variety of conditions. The first practical exercises of Soviet cosmonauts consisted of special training under conditions of high vacuum. For this purpose a full-size mockup of the "Voskhod-2" spacecraft, complete with airlock, was placed in a thermobarochamber. Conditions modelling the conditions of

*Numbers given in the margin indicate the pagination in the original foreign text.

flight were maintained inside the ship and a vacuum was created on the outside.

In full space regalia, I and the commander of the ship rehearsed the entire airlock and egress procedure. Our activities were monitored during these rehearsals by experienced specialists using television cameras located inside and outside the ship. Every one of our movements, every act, every step was carefully recorded in motion pictures, then analyzed and perfected. Working with the specialists we found answers and continued to sharpen our actions, until they were automatic and their high-quality performance was fully assured.

Our activities while in open space, behavior under conditions of free fall, and spacecraft egress and ingress procedures were worked out in a "weightlessness tank" carried on a laboratory plane. Ten times we went up into the air, and in the short intervals of weightlessness, worked out step by step every detail of the egress into space.

Much effort, labor, ingenuity, persistence, and know-how went into the /3 creation of training devices providing the closest possible approximation of training to actual flight conditions. This made it possible for our crew, under ground conditions, to "feel out" space to some degree and to lay a solid practical groundwork of habit for their activities. And it is no wonder that in making the actual spaceflight, including the egress into space, we were essentially only doing what we had already done many times on Earth. We were not called upon to do anything unusual, since the system of training on the ground was well thought out.

Redundancy was provided for many of the ship's systems, including the life support system, ship control system, and landing system. In case one system should break down, the other could immediately be placed in operation. In our training program we rehearsed not only the official flight operations plan, but also action to be taken in a variety of emergency situations. In particular, great care was taken in working out a procedure for the commander to help the second pilot re-enter the spacecraft. If anything had happened to me in open space and I had been unable to re-enter the ship, the commander would very quickly have come to my aid. As you already know, my friend and commanding officer did not have to do this. However, he did have to make a manual landing because of failure of one of the commands of the automatic landing cycle. With this problem P. I. Belyayev dealt brilliantly. The aviation training, or more exactly, the flight training of the cosmonauts serves better than any other to inculcate the qualities necessary in a cosmonaut.

At the present stage in the conquest of space, the individual physical /4 qualities of cosmonauts are of great importance: strength, endurance, tolerance of accelerations and weightlessness, and a host of others. For this reason this aspect of our training also received great attention during our preparation for flight. During the training period I rode more than 1000 km on a bicycle, ran more than 250 km, and travelled a like distance on skis. And this is not even to mention gymnastic exercises using athletic equipment and other forms of physical education.

We were aware that the experiment of egress from the spacecraft into open space, to be performed for the first time, would be complicated and would require extremely careful execution. For this reason we conducted the whole egress operation strictly by the book, rigorously adhering to the planned sequence of operations. The extravehicular activity was executed with an autonomous backpack life support system. The backpack system was donned in the cabin of the spacecraft immediately before entering the airlock. After preparation for egress, the ship and backpack life support systems and the equipment for recording the cosmonaut's physiological indices and hygienic parameters inside the suit were checked out one more time. Excess pressure inside the suit could be maintained at either 0.4 atm or 0.27 atm as the cosmonaut desired. I executed the extravehicular activity at an excess pressure inside the suit of 0.4 atm. Before reentering the ship from open space I set the pressure at 0.27 atm. During free fall I was connected to the ship by a special lifeline and was in radiotelephone contact with Earth and with the spacecraft commander. The lifeline permitted travel to a distance of 5 m from the airlock's rim. The spacecraft commander observed my activities by television, and monitored suit pressure and pulse and respiration rates by instrument.

I remained in open space for 10 min, or counting egress and ingress /5 time in the airlock, for 20 min. Even though my eyes were covered by a rather dense light filter, I could clearly see the Earth, bright clouds, the shores of the Black Sea, the Caucasus range, large rivers, cities, bays, and gulfs. The sphere of the heavens looked like black velvet strewn with unwinking stars and the bright disk of the Sun. The spacecraft itself was a very impressive sight, lit up by the Sun and the light of the Earth and bristling with various spear-like antennas.

"Swimming" in free space near the ship, one cannot make any sudden movements which will produce significant linear accelerations relative to the ship. I already knew this while still on Earth, and had worked out my movements in the flying laboratory during periods of weightlessness. Therefore exit from and entry into the airlock were accomplished by very gently pushing myself out of the airlock and by pulling myself along by my lifeline. Incidentally, by certain maneuvers with the lifeline it is even possible to control the attitude of one's body in space, or slow down or speed up one's angular rotation, which I had also done in practice.

The effects of shifts in the ship's center of gravity was very interesting. All my movements inside the airlock, and also my movements away from and towards it, had an effect on the position of the ship in space. These displacements were small, but were actually visible to the eye. Sound conduction through ship structures was also good. P. I. Belyayev, in addition to all the officially designed systems for monitoring me, had at his disposal an unofficial sound system. As he afterwards told me, he literally heard my every step in space.

One of the aims of the extravehicular activity was to determine work /6
capacity while in free fall in open space. It was with this particular end in view that the experiment involving dismounting the motion picture camera located on a special mount on the rim of the hatch was performed. This task was carried out, and the frames taken with that camera have been seen by many people.

During my entire stay in open space I felt splendid, my spirit was high, and when the scheduled time came for me to return to the ship, as I was reminded to do by the commander, it was with regret that I began to carry out his command. Re-entry into the ship did not present any particular difficulties, if we do not count the awkwardness connected with rescuing the motion picture camera. One hand was busy with the camera while the other was providing a grip for re-entering, and it was difficult to switch hands in order to complete the maneuver. Letting go of the camera was risky, since it could have "swum off" into space. In the end I managed to deal with this problem, and once the hatch of the airlock was closed everything reverted once more to the way it had been during training, strictly according to plan, sure and certain.

That part of the experimental program assigned to me for execution during extravehicular activity had as its basic aim the evaluation of the possibilities and special features of the performance by cosmonauts of various work operations. The materials obtained lead first of all to the conclusion that the conditions of extravehicular activity cause no serious specific changes in the state of the psychophysiological functions. Thus, for example, pulse rate dynamics during the extravehicular activity phase coincide to a great degree with the data obtained during the ground barochamber studies in the spacecraft mockup (fig. 1). /7
It is worth noting that the first moment of separation from the ship, the first step into space, was not accompanied by any sudden increase in emotional tension, as might have been expected. This was subjectively noticed by me and objectively confirmed by the respiration and pulse rate data given in the text figure (fig. 2). This circumstance is primarily due to our high level of preparedness, as well as to the characteristics of my program of action. That moment of the program was specially loaded up with a number of responsible operations, such as: determining coordinates for spatial orientation, checking and readying the motion picture camera, checking the airlock, and so forth. Thus there was neither place nor time for supernumerary emotions. It should be noted that these circumstances also played a positive role in the prevention of possible vestibular disturbances. I noted no unpleasant subjective sensations, despite the fact that I executed several revolutions in more than one plane in the course of the program.

During flight training particular attention was given to the selection of a "base" system of coordinates for the cosmonaut to use in orienting himself in space after egress from the ship, i.e., to his defining an "up--down" axis. Flight experience has shown the preliminary selection and firm mastery of such a system by the cosmonaut to be necessary. It seems to us that basing the arbitrary system of coordinates on the basic ship axes, as we did, is the best choice among the possible variants.

Evaluation of the condition and work capacity of the cosmonaut immediately after the operation of egress into space is of definite interest. One of /8
the criteria chosen for this evaluation was to have the cosmonaut perform tracking operations with a model control system. The cosmonaut was required to observe a moving signal dot on the screen of this model, which he could track with a moving pointer controlled by a system of levers. It was noted that the

quality of performance of this task immediately after egress into space was only slightly lower than that obtained 2 hrs before launch. The above is illustrated by the graph of autocorrelative functions given in the text (fig. 3). It may be supposed that this last material will find definite application to the choice of design and control principles of autonomous motors for cosmonauts outside the ship.

Pavel Ivanovich Belyayev has already described the remainder of the flight to you.

In conclusion I wish to say that the experiment in extravehicular activity in open space, repeated shortly afterwards by the American astronaut Edward White, fully confirms that it is possible for humans to perform certain work operations in open space. This applies both to work of a physical nature and to the conduct of scientific observations.

We understand that this is only the beginning. The way to the mastery of space is not an easy one. Even so, what has already been accomplished to date represents human progress in the conquest of space and the mastery of the secrets of the Universe. It seems to me that the time is close at hand when multiman scientific research space labs manned by periodically rotated crews will appear in orbits around the Earth, to be followed by permanent space stations and manned landings on the Moon and the other planets of the solar system. /9

The possibilities of modern space technology are truly unlimited; the most important thing is that these possibilities be exploited to peaceful ends, for the benefit of all mankind, and not to its detriment.

We, the Soviet cosmonauts, are very proud that while being among the pioneers of space, we have on our flights solved scientific problems having purely peaceful purposes.